

Recovery Plan For Carolina Heelsplitter (*Lasmisgona decorata*) Lea



**U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia**

RECOVERY PLAN

for

Carolina Heelsplitter (*Lasmigona decorata*) Lea

Prepared by

John A. Fridell
Asheville Field Office
U.S. Fish and Wildlife Service
Asheville, North Carolina

for

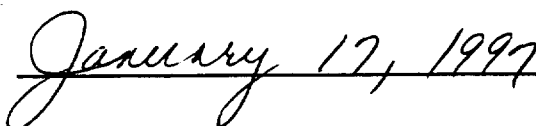
U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

Approved:



Noreen K. Clough, Regional Director, Southeast Region
U.S. Fish and Wildlife Service

Date:



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By approving this document, the Regional Director certifies that the data used in its development represent the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in the development of the plan are available in the administrative record, located at the Asheville, North Carolina, Field Office.

LITERATURE CITATION of this document should read as follows:

U.S. Fish and Wildlife Service. 1996. Carolina Heelsplitter Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, GA. 30 pp.

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EXECUTIVE SUMMARY

Current Status: The Carolina heelsplitter was listed as endangered on June 30, 1993. There are only four known remaining populations of this species--two in North Carolina and two in South Carolina. The North Carolina populations are located in Goose Creek (Pee Dee River system) and Waxhaw Creek (Catawba River system) in Union County. In South Carolina, there is one population in the Lynches River (Pee Dee River system) in Lancaster, Chesterfield, and Kershaw Counties that extends into Flat Creek (a small tributary to the Lynches River) in Lancaster County. The other South Carolina population occurs in Turkey Creek (Savannah River system) and two of its tributaries, Mountain and Beaverdam Creeks, in Edgefield County. The complete historic range of the species is unknown, but available information indicates it was once fairly widely distributed in the Catawba and Pee Dee River systems in North Carolina and the Pee Dee and Savannah Rivers systems (and possibly the Saluda River system) in South Carolina.

Habitat Requirements and Limiting Factors: Presently, the species is known to occur in short stream reaches in only six small streams and one small river. It is usually found in mud, muddy sand, or muddy gravel substrates along stable, well-shaded stream banks (Keferl and Shelly 1988, Keferl 1991). However, live specimens were found in Mountain Creek in South Carolina, in the main channel of the stream, in a relatively clean substrate comprised of sand, gravel, and cobble. The stability of stream banks appears to be very important to the species (Keferl 1991). Water quality and habitat degradation resulting from impoundments and stream channelization projects, point and nonpoint sources of siltation, and other pollutants appear to be major factors in reducing the species' distribution and reproductive capacity. Unless new populations are found or created and existing populations are maintained, this species will likely become extinct in the foreseeable future.

Recovery Objective: Delisting.

Recovery Criteria: Establish four distinct viable populations that are protected from present and foreseeable threats, with at least one population each in the Catawba, Pee Dee, and Savannah River systems, to downlist. Establish six distinct viable populations that are protected from present and foreseeable threats, with at least one population each in the Catawba, Pee Dee, and Savannah River systems, to delist.

Actions Needed:

1. Use existing legislation/regulations to protect the species.
2. Elicit support for recovery efforts through the development and utilization of an information/education program.
3. Search for new populations and monitor existing populations.
4. Determine the species' life history, habitat requirements, and threats.
5. Implement management and alleviate threats to the species' existence.
6. Through augmentation, reintroduction, and protection, establish six viable populations.
7. Develop and implement cryopreservation of the species.

Cost (\$000s):

YEAR	NEED 1	NEED 2	NEED 3	NEED 4	NEED 5	NEED 6	NEED 7	TOTAL
1997	5.5	8.0	6.0	25.0	0.0	30.0	8.5	83.0
1998	5.5	5.5	6.0	25.0	25.0	30.0	8.5	105.5
1999	5.5	3.0	4.0	25.0	25.0	30.0	2.0	94.5
2000	5.5	0.0	0.0	0.0	25.0	10.0	2.0	42.5
2001	5.5	0.0	4.0	0.0	?	10.0	2.0	21.5*
2002	5.5	2.0	0.0	0.0	?	10.0	2.0	19.5*
2003	5.5	0.0	5.5	0.0	?	0.0	2.0	13.0*
2004	5.5	0.0	0.0	0.0	?	0.0	2.0	7.5*
2005	5.5	2.0	5.5	0.0	?	0.0	2.0	15.0*
2006	5.5	0.0	0.0	0.0	?	0.0	2.0	7.5*
2007	5.5	0.0	5.5	0.0	?	0.0	2.0	13.0*
TOTAL	60.5	20.5	36.5	75.0	75.0*	120.0	35.0	422.5*

*Habitat improvement costs needed for the species' recovery will not be known until the magnitude of specific threats is determined through research.

Date of Recovery: The downlisting and delisting dates cannot be estimated at this time. As mussels do not reproduce until about age 5, more than 10 years is needed to document reproduction and assess viability.

TABLE OF CONTENTS

Page

PART I:

INTRODUCTION	1
Description, Ecology, and Life History	1
Distribution and Threats to Its Continued Existence	2

PART II:

RECOVERY	6
A. Recovery Objectives	6
B. Narrative Outline	8
C. Literature Cited	13

PART III:

IMPLEMENTATION SCHEDULE	16
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PART IV:

LIST OF RECIPIENTS	19
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PART I

INTRODUCTION

The Carolina heelsplitter (*Lasmigona decorata*) was listed as an endangered species on June 30, 1993 (U.S. Fish and Wildlife Service 1993). This freshwater mussel inhabits cool, slow-moving, small- to medium-sized streams and rivers. The Carolina heelsplitter currently has a very fragmented, relict distribution but historically was known from several locations within the Catawba and Pee Dee River systems in North Carolina and the Pee Dee and Savannah River systems, and possibly the Saluda River system, in South Carolina. The species is presently known to be surviving in only six streams and one small river--Waxhaw Creek (Catawba River system) and Goose Creek (Pee Dee River system), both in Union County, North Carolina; Lynches River (Pee Dee River system), in Chesterfield, Lancaster, and Kershaw Counties, South Carolina; Flat Creek (Pee Dee River system), a tributary to the Lynches River, in Lancaster County, South Carolina; and Turkey Creek (Savannah River system) and Mountain and Beaverdam Creeks (tributaries to Turkey Creek), all in Edgefield County, South Carolina. The species has been reduced to a few short reaches of each of these streams, primarily as a result of impoundments and the general deterioration of water quality resulting from siltation and other pollutants contributed as a result of poor land-use practices.

Description, Ecology, and Life History

The Carolina heelsplitter was originally described as *Unio decoratus* by Lea (1852). In 1970, this species was synonymized with *Lasmigona subviridis* (Conrad 1835) by Johnson (1970). Clarke (1985) recognized the Carolina heelsplitter as a distinct species, *Lasmigona decorata*, and synonymized *Unio charlottensis* (Lea 1863) and *Unio insolidus* (Lea 1872) with *Lasmigona decorata*.

The Carolina heelsplitter has an ovate, trapezoid-shaped, unsculptured shell. The shell of the largest known specimen of the species measures 114.8 millimeters (mm [4.6 inches]) in length, 39.0 mm (1.56 inches) in width, and 68.0 mm (2.7 inches) in height (Keferl 1991). The shell's outer surface varies from greenish brown to dark brown in color, and shells from younger specimens have faint greenish brown or black rays. The nacre (inside surface) is often pearly white to bluish white, grading to orange in the area of the umbo (Keferl 1991). However, in older specimens, the entire nacre may be a mottled pale orange (Keferl 1991).

Because of its rarity, little is known of the biology of the Carolina heelsplitter. Historically, the species was reported from small to large streams and rivers as well as ponds. The ponds referred to in historic records are believed to have been mill ponds on some of the smaller streams within the species' historic range (Keferl 1991). Presently, the species is known to occur in only six small streams and one small river and is usually found in mud, muddy sand, or muddy gravel substrates along stable, well-shaded stream banks (Keferl and Shelly 1988, Keferl 1991). However, in Mountain Creek in Edgefield County, South Carolina, two live individuals were found near the center of the stream channel in a relatively silt-free substrate comprised primarily

of a mixture of sand, gravel, and cobble (author's personal observation, 1995). It is conceivable that this is the preferred habitat type for the species and that in other areas degradation of the gravelly substrates has restricted the species to less suitable habitats. The stability of stream banks appears to be very important to the species (Keferl 1991).

Like other freshwater mussels, the Carolina heelsplitter feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton. The reproductive cycle of the Carolina heelsplitter is likely similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which are then parasitized for a short time while the glochidia develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom where they continue to develop, provided they land in a suitable substrate with the correct water conditions. The Carolina heelsplitter's life span, the fish host species, and many other aspects of its life history are unknown.

Distribution and Threats to Its Continued Existence

Prior to 1987 the Carolina heelsplitter had not been found since the mid-19th century (Keferl and Shelly 1988, Keferl 1991). Historically, the species was collected from the Catawba River, Mecklenburg County, North Carolina; several streams and ponds in the Catawba River system around the Charlotte area of Mecklenburg County, North Carolina; one small stream in the Pee Dee River system in Cabarrus County, North Carolina; one "pond" in the Pee Dee River system in Union County, North Carolina; and an area in South Carolina (covering portions of both the Saluda and Savannah River systems) referred to only as the Abbeville District, a terminology no longer employed (Clarke 1985, Keferl and Shelly 1988, Keferl 1991). The records from the Abbeville District, South Carolina, were previously believed to have been from the Saluda River system (Clarke 1985, Keferl and Shelly 1988, Keferl 1991). However, as a result of surveys funded by the U.S. Forest Service, a population of the Carolina heelsplitter was discovered in the spring of 1995 in the Savannah River system (Turkey Creek and two of its tributaries). Therefore, the historic records from the Abbeville District may have been from either the Saluda River system or the Savannah River system or both.

Recent collection records (Keferl and Shelly 1988, Keferl 1991, Alderman 1995) indicate that the Carolina heelsplitter has been eliminated from all but one of the streams from which it was known to have been originally collected. Only four populations of the species are presently known to exist. One small remnant population occurs in the Catawba River system in Waxhaw Creek, a tributary to the Catawba River, in Union County, North Carolina; another small population occurs in a short stretch of Goose Creek, a tributary to the Rocky River in the Pee Dee River system, in Union County, North Carolina; a third, slightly larger population, survives in the Lynches River, part of the Pee Dee River system, in Chesterfield, Lancaster, and Kershaw

Counties, South Carolina, and extends into Flat Creek, a tributary to the Lynches River in Lancaster County, South Carolina. In the Savannah River system the species is known only from Turkey Creek and two of its tributaries, Mountain Creek and Beaverdam Creek, in Edgefield County, South Carolina. No evidence of a surviving population has been found in recent years in the Saluda River system (Keferl 1991).

The decline in the species throughout its range has been attributed to several factors, including siltation resulting from poorly implemented agricultural, forestry, and development activities; golf course construction; road construction and maintenance; runoff and discharge of municipal, industrial, and agricultural pollutants; habitat alterations associated with impoundments, channelization, dredging, and sand mining operations; and other natural and human-related factors that adversely modify the aquatic environment. Many of these same factors threaten the remaining populations of the species.

Waxhaw Creek and Goose Creek are small streams containing a limited amount of suitable habitat for the Carolina heelsplitter (E. Keferl, Brunswick College, personal communication, 1991). The two populations within Waxhaw and Goose Creeks appear to be extremely small and restricted to a few scattered sites within short reaches of each of these creeks. The Lynches River/Flat Creek population also appears to be relatively small and is restricted to a few scattered sites along short reaches of these streams (Keferl, personal communication, 1991). The Turkey Creek/Mountain Creek/Beaverdam Creek population was only recently discovered (Alderman 1995), and little is presently known about the status and abundance of the species in these three streams. The low number of individuals and the restricted range of each of the surviving populations make them extremely vulnerable to extirpation from a single catastrophic event or activity, such as a toxic chemical spill or major channel alteration. Also, the existing and potential future land-uses of the surrounding area threaten the habitat and water quality of all four populations with increased discharge or runoff of silt, sediments, and organic and chemical pollutants.

Land-clearing and disturbance activities implemented without proper sedimentation control pose a significant threat to the species' continued existence. Mussels are sedentary and are not able to move long distances to more suitable areas in response to heavy silt loads. Natural sedimentation resulting from seasonal storm events probably does not significantly affect mussels, but human activities often create excessively heavy silt loads that can have severe effects on mussels and other aquatic organisms. Siltation has been documented to adversely affect native freshwater mussels both directly and indirectly. Siltation degrades water and substrate quality, limiting the available habitat for freshwater mussels (and their fish hosts); irritates and clogs the gills of filter-feeding mussels, resulting in reduced feeding and respiration; smothers mussels if sufficient accumulation occurs; and increases the potential exposure of the mussels to other pollutants (Ellis 1936, Marking and Bills 1979, Kat 1982). Ellis (1936) found that less than 1 inch of sediment deposition caused high mortality in most mussel species. Sediment accumulations that are less than lethal to adults may adversely affect or prevent recruitment of juvenile mussels into the population through the direct mortality of juvenile mussels or effects to the species' fish host(s).

The stability of the stream banks appears to be very important to the Carolina heelsplitter. Keferl (1991) noted that he found the highest concentrations of the species in undercuts and along shaded banks stabilized with extensive tree roots, a buried log, or rocks. Development, road construction, and other land-clearing activities can result in increased storm-water runoff, resulting in increased scouring and erosion of the stream banks. Clearing of trees up to or along the stream banks results in the destabilization and erosion of the banks.

Heavy nutrient and pollutant loads (i.e., fertilizers, organic wastes, pesticides, heavy metals, oil, salts, etc.) from wastewater treatment facility effluents, agricultural activities (crop and livestock), forestry operations, urban and rural residential and industrial areas, highways, and other point and nonpoint sources also threaten the continued existence of the remaining populations. Though at present this appears to be more of a problem in the Lynches River than in the other streams, it will likely become more of a threat to the other three populations as development increases within their drainages.

In the early 1900s, Ortmann (1909) noted that unionids (mussels) are the most reliable indicator of stream pollution. Keller and Zam (1991) concluded that mussels were more sensitive to metals than commonly tested fish and aquatic insects. The life cycle of native mussels makes the reproductive stages especially vulnerable to pesticides and other pollutants (Ingram 1957, Stein 1971, Fuller 1974, Gardner *et al.* 1976).

Effluent from sewage treatment facilities can be a significant source of pollution that can severely affect the diversity and abundance of aquatic mollusks. The toxicity of chlorinated sewage effluents to aquatic life is well documented (Brungs 1976, Tsai 1975, Bellanca and Bailey 1977, U.S. Environmental Protection Agency 1985, Goudreau *et al.* 1988), and mussel glochidia rank among the most sensitive invertebrates in their intolerance to toxicants present in sewage effluents (Goudreau *et al.* 1988). Goudreau *et al.* (1988) found that the recovery of mussel populations may not occur for up to 2 miles below the discharge points of chlorinated sewage effluent.

Impoundments are also believed to be a major factor contributing to the decline of the Carolina heelsplitter. Large portions of the Savannah, Saluda, Catawba, and upper Pee Dee River systems have been impounded. The effects of impoundments on mussels are also well documented. Closure of dams changes the habitat from a lotic to lentic condition. Depth increases, flow decreases, and silt accumulates on the bottom. Fish communities change, and host fish species may be eliminated. Mussel communities change; species requiring clean gravel and sand substrate are eliminated (Bates 1962). In addition, dams result in the fragmentation of populations, making the surviving isolated population segments more vulnerable to extirpation.

Exotic species pose another serious threat to the Carolina heelsplitter. The Asiatic clam (*Corbicula fluminea*), 1 of 204 introduced mollusk species in North America (Dundee 1969), was first discovered in the United States in the Columbia River in Oregon in 1939. By 1972 the species could be found in most of the major river systems throughout the United States

(Fuller and Powell 1973). *Corbicula fluminea* has become well established in all of the streams still supporting surviving populations of the Carolina heelsplitter. The extent of the threat that *C. fluminea* presents to the heelsplitter and other native mussel populations is presently unknown and requires further study. Many malacologists are concerned about the possibility of a competitive interaction for space, food, and oxygen between *C. fluminea* and native bivalves. Competition may not occur among adults but, rather, at the juvenile stage (Neves and Widlak 1987). Because of its restricted distribution and apparent low population levels, *L. decorata* may be unable to withstand vigorous competition.

The zebra mussel (*Dreissena polymorpha*), another exotic freshwater mussel species, is a native of the drainage basins of the Black, Caspian, and Aral Seas. It was first introduced into Lake St. Clair in the mid- to late 1980s. In only a few years it colonized all five of the Great Lakes and is rapidly expanding into the surrounding river basins, including those of the South Atlantic Slope (O'Neill and MacNeill 1991). Many biologists believe the species may ultimately infest most areas of North America south of central Canada and north of the Florida Panhandle (O'Neill and MacNeill 1991). *Dreissena polymorpha* is a prolific breeder; once established in an area, it attaches in large numbers to any firm nontoxic surface, including other living organisms (i.e., crayfish, snails, other mussels, etc.) (O'Neill and MacNeill 1991). Numerous live and dead native mussels have been observed covered with extensive growths of *D. polymorpha*, and there are signs that native mussel populations in Lake St. Clair are disappearing rapidly, coincident with the *D. polymorpha* colonization (O'Neill and MacNeill 1991). Aside from the direct interactions between *D. polymorpha* and native benthic organisms, there is concern that the tremendous filtering activity exerted by high-density populations of the species could disrupt the natural food chain and affect the entire aquatic communities of infested lakes and streams (Hebert *et al.* 1991, O'Neill and MacNeill 1991, Weigmann *et al.* 1991).

The introduction of nonindigenous fish species can also result in significant disruption of the aquatic communities. The effects of predation on endemic species and/or competition for food and breeding habitat between nonindigenous and native fish species can result in drastic declines or the elimination of the native fish fauna, including species necessary for the Carolina heelsplitter and other endemic mussels to complete their reproductive cycles.

PART II

RECOVERY

A. Recovery Objectives

The immediate goal of this recovery plan is to maintain the only known surviving populations of *L. decorata* and to protect its remaining habitat from present and foreseeable threats. As stated previously, there are only four known surviving populations of this species--two in North Carolina and two in South Carolina. Of these, only the South Carolina populations appear to be relatively healthy (the two North Carolina populations are extremely small). Lack of proper protection and management of these populations, particularly the two populations in South Carolina, will preclude recovery of the Carolina heelsplitter and will ultimately lead to the species' extinction.

The intermediate goal of this recovery plan is to restore and maintain *L. decorata* throughout a significant portion of its historic range in the Catawba, Pee Dee, Savannah, and Saluda River systems and to downlist the species from endangered to threatened status. Though the ultimate goal is to recover the species to the point where it can be removed from the Federal List of Endangered and Threatened Wildlife and Plants, full recovery of the Carolina heelsplitter may not be possible. The species appears to have a very restricted distribution, and much of the habitat within its known historic range may not be suitable for reintroductions.

The Carolina heelsplitter will be considered for downlisting to threatened status when the likelihood of the species' becoming extinct in the foreseeable future has been eliminated by the achievement of the following criteria:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, a total of four distinct viable populations exist. A viable population is defined as a naturally reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural environmental changes. The number of individuals needed to reach a viable population will be determined as one of the recovery tasks. These four populations must be distributed throughout the species' known historic range, with at least one each in the Catawba, Pee Dee, and Savannah River systems. Also, these populations must be extensive enough that it is unlikely that a single event would eliminate or significantly reduce one or more of them.
2. Two distinct naturally reproduced year classes exist within each of the four populations. One of these year classes must have been produced within the 5 years prior to the time the species is reclassified from endangered to threatened. Within the year prior to the

downlisting date, gravid females and the mussel's host fish must be present in each populated river/stream reach.

3. Biological and ecological studies have been completed and any required recovery measures developed and implemented from these studies are beginning to show signs of success, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the four populations.
4. Where habitat has been degraded, noticeable improvements in channel stability, water and substrate quality, and associated biota have occurred.
5. Each of these four populations and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence.

The Carolina heelsplitter will be considered for removal from Endangered Species Act protection when the likelihood of the species' becoming threatened in the foreseeable future has been eliminated by the achievement of the following criteria:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, a total of six distinct viable populations exist. These populations must be distributed throughout the species' known historic range, with at least one each in the Catawba, Pee Dee, and Savannah River systems. (If additional evidence is found indicating that the Carolina heelsplitter also historically occurred in the Saluda River system, then this river system should also be added to the list.) Also, these populations must be extensive enough that it is unlikely that a single event would eliminate or significantly reduce one or more of them.
2. Three distinct, naturally reproduced year classes exist within each of the six populations. One of these year classes must have been produced within the 10 years prior to the recovery date and another year class within the 5 years prior to the recovery date. Within the year prior to the recovery date, gravid females and the mussel's host fish must be present in each river.
3. Studies of the mussel's biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of these six populations.
4. Where habitat has been degraded, noticeable improvements in channel stability, water and substrate quality, and associated biota have occurred.
5. Each of these six populations and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence.

C. Narrative Outline

1. **Maintain the existing populations and habitat of the Carolina heelsplitter.** At present there are only four known surviving populations of *L. decorata*--one each in Waxhaw Creek and Goose Creek in Union County, North Carolina; one in a short reach of the Lynches River along the county lines of Chesterfield, Lancaster, and Kershaw Counties, South Carolina, extending into Flat Creek in Lancaster County, South Carolina; and one in Turkey Creek and two of its tributaries, Mountain and Beaverdam Creeks, in Edgefield County, South Carolina. If the species is to survive and expand its range, protection of the existing populations and remaining areas of suitable habitat is vital. Unless immediate steps are taken to stop the decline of the species and protect and secure these relict populations, the species will likely be extinct in the very near future.

- 1.1 **Use existing legislation and regulations (Federal Endangered Species Act, Federal and State water quality regulations, stream alteration regulations, surface mining laws, etc.) to protect the species and its habitat.** Prior to and during implementation of this recovery plan, the present populations can be protected only by full enforcement of existing laws and regulations. Unless this objective is met, any recovery activities would be essentially moot. Habitat and water quality degradation have severely reduced the species' range and continue to threaten the only remaining populations. Complete compliance with Federal and State laws and regulations designed to protect water and habitat quality must be ensured if the Carolina heelsplitter is to survive.

- 1.2 **Work with appropriate Federal and State regulatory and review agencies to identify and assess projects and/or activities that could have negative effects on the species and to ensure incorporation of measures for protecting the species and its habitat into such activities.** Through Section 7 of the Endangered Species Act, the Fish and Wildlife Coordination Act, Clean Water Act, etc., Federal and State regulatory and review agencies must work together to carefully evaluate and identify actions and activities with the potential to adversely affect the species and its habitat. Once impacts have been identified, regulatory/permitting agencies must be encouraged to utilize their authorities to ensure that the species and its habitat are adequately protected from such activities.

- 1.3 **Solicit help in protecting and enhancing the species and its essential habitat.** Assistance and support of conservation groups, local governments, and regional and local planners will be essential in meeting the goal of recovering the Carolina heelsplitter. Also, the support of local industrial, business, silvicultural, and agricultural communities, as well as local residents, will be needed. Construction, forestry, and agricultural "best management practices" must be implemented by all landowners, and National Pollution Discharge Elimination System Permit compliance must be encouraged and enforced. Local land-use planning is needed to protect water

resources, and individuals need to be informed as to why and how they should protect creeks and rivers. Without a commitment from the local people who have an influence on habitat quality in the streams inhabited by the species, recovery efforts will be met with little success.

1.3.1 Meet with local government officials and regional and local planners to inform them of our plans to attempt recovery and solicit their support for protection of the species and its essential habitat.

1.3.2 Meet with local business, farming, logging, mining, and industry interests and elicit their support in implementing protective actions.

1.3.3 Develop an educational program using such items as slide/tape shows, brochures, etc. Present this material to business groups, civic groups, schools, church organizations, etc. Educational material outlining the recovery goals and emphasizing the benefits of maintaining and upgrading habitat quality will be extremely useful in informing the public of our actions and implementing Tasks 1.3.1 and 1.3.2.

1.4 Encourage the establishment of mussel sanctuaries, protective water quality designations, stream buffer zones, and other protection strategies as a means of protecting present and reintroduced populations. The U.S. Fish and Wildlife Service should work with the U.S. Environmental Protection Agency and appropriate State agencies in North Carolina and South Carolina to have special status assigned to river and stream reaches inhabited by the species that would provide increased protection to the Carolina heelsplitter. They should also work together to identify potential sources of water contamination within the Pee Dee, Catawba, and Savannah River systems and determine measures for reducing and/or eliminating these sources.

1.5 Consider and, if necessary, use land acquisition as a means of protecting the species' essential habitat.

2. Determine threats to the species, conduct research necessary for the species' management and recovery, and implement management actions where needed.

2.1 Conduct life history research on the species, to include such factors as reproduction, food habits, age and growth, and mortality rates, and characterize the species' habitat requirements (relevant physical, biological, and chemical components) for all life history stages. Research should be done to determine the time and duration of the spawning season, when fertilization occurs, how long glochidia are held in the females' marsupia, time of year they are released, and the required fish host(s). Fertilization rate should also be investigated. Detailed knowledge of the habitat requirements of the species; community structures of

associated mussel and fish species; and how these biotic and abiotic factors affect reproduction, growth, and mortality rates of the Carolina heelsplitter are needed in order to focus management and recovery efforts on specific problems within the species' habitat. Unless the life cycle and environmental requirements of all life history stages of the species are defined, recovery efforts may be inconsequential or misdirected.

2.2 Identify and eliminate current and future threats to the species' survival. Water quality and habitat degradation resulting from siltation and other pollutants from numerous point and nonpoint sources appear to be major factors in the reduction of the species' throughout its range. The nature of and mechanisms by which these and other factors impact the species are not entirely understood. The extent to which the species can withstand these adverse impacts is unknown. To minimize and eliminate these threats, where necessary to meet recovery, the information gathered in Task 2.1 must be used to target and correct specific problem areas and determine the specific causative agent(s).

2.3 Investigate relationships with nonindigenous species and prevent introduction/spread. Of rising concern among malacologists is the potential effect of the introduced Asiatic clam (*Corbicula fluminea*) on native freshwater mussels. Also, another exotic clam, the zebra mussel (*Dreissena polymorpha*), has recently invaded the Great Lakes and adjacent river systems. Adverse impacts to endemic mussels have been noted. The zebra mussel has not yet been observed in the Saluda, Catawba, or Pee Dee River systems. However, the species has spread rapidly from the Great Lakes area into surrounding drainage basins, and it is expected to invade other basins in the near future. Established populations of introduced fish species may also pose a significant threat to the survival of the Carolina heelsplitter by displacing the native fish fauna, thereby affecting the heelsplitter's reproductive cycle. The relationship between these nonindigenous species and the native fauna should be thoroughly investigated, and measures should be implemented (where feasible) to minimize their impact and control their expansion.

2.4 Based on the biological data and threat analyses, investigate the need for management, including habitat improvement. Implement management actions where needed to secure viable populations. Specific components of the Carolina heelsplitter's habitat may be lacking, and this may limit the species' potential expansion. Habitat improvement programs may be needed to alleviate limiting factors.

2.5 Determine the number of individuals required to maintain a viable population and the genetic viability of existing populations. Long-term management of Carolina heelsplitter populations will require a knowledge of the genetic composition of each population, the number of individuals necessary to maintain genetic viability,

and an understanding of the factors that affect viability. If possible, such studies should develop and use techniques that minimize the sacrifice of individuals from natural populations (examples include salvage and analysis of individuals killed incidentally or collected from fresh muskrat middens; nonlethal analysis of individuals, using small, excised tissue samples; production of an experimental, cultured population; and the development of these techniques, using more common surrogate species).

3. Search for additional populations and/or habitat suitable for reintroduction efforts.

It is possible that some relic populations have been missed, and further study may yield additional populations and/or suitable habitat for reintroductions. Also, surveys are needed to record and monitor any future range reductions or expansions.

4. Determine the feasibility of augmenting extant populations and reestablishing populations within the species' historic range and reintroduce where feasible.

Presently there are only four known remaining populations of the Carolina heelsplitter. Two of these populations--Waxhaw Creek and Goose Creek--appear to be extremely small. For the species to survive, it will likely be necessary that these populations be supplemented to enable them to reach a viable size. The complete historic range of the species is unknown, but available information indicates it once occurred in several locations within the Catawba and Pee Dee River systems in North Carolina and the Pee Dee and Savannah River systems (and possibly the Saluda River system) in South Carolina. There may be areas within the species' historic range that could support reestablished populations. However, because the two South Carolina populations are presently the only sources of individuals for transplants and are themselves relatively small, it is vital that these populations be protected in order for them to increase in size before any transplants using individuals from the wild are attempted.

4.1 Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations. The two South Carolina populations of the species may be able to expand naturally if environmental conditions are improved and maintained. However, even if conditions are improved in the Goose and Waxhaw Creeks, these populations may be too small to expand naturally and will likely need to be supplemented in order to continue to survive and reach a viable size. Implementation of this task will be based on population size, habitat quality, and the likelihood of long-term benefits from the task.

4.2 Develop a successful technique for reestablishing and augmenting populations.

Sufficient specimens of *L. decorata* are not currently available to allow for the translocation of enough individuals of the species to reestablish viable populations. There is an immediate and urgent need to develop techniques for propagating and holding mussels for prolonged periods and rearing juveniles to a size and age at which

they can be successfully transplanted. Reintroduction techniques must also be developed to ensure success.

- 4.3 **Coordinate with appropriate Federal and State agency personnel, local governments, and interested parties to identify habitat suitable for augmentation and reintroductions and those most easily protected from further threats.**
- 4.4 **Augment existing populations where needed, establish new populations within the species' historic range, and evaluate success.** Using techniques developed in Task 4.2, introduce and monitor success.
- 4.5 **Implement the same protective measures for any introduced populations as outlined for established populations.**
5. **Develop and implement cryogenic techniques to preserve the species' genetic material until such time as conditions are suitable for reintroduction.** Artificial propagation techniques may be able to provide juvenile mussels for transplants. However, at this time habitat conditions within the species' historic range may not be suitable for reintroduction to succeed. Cryogenic preservation of the Carolina heelsplitter could maintain genetic material from all the extant populations until habitat is suitable for reestablishment of the species (much like seed banks for endangered plants). Additionally, if a population was lost to a catastrophic event, such as a toxic chemical spill, cryogenic preservation could allow for the eventual reestablishment of the population using genetic material preserved from that population.
6. **Develop and implement a program to monitor population levels and habitat conditions of existing populations, as well as newly discovered, introduced, or expanding populations.** During and after recovery actions are implemented, the status of the species and its habitat must be monitored to assess any progress toward recovery. Quantitative samples should be taken to determine densities of adults and juveniles. A concerted effort should be made to find gravid females and juveniles in order to determine if reproduction and recruitment are occurring. Monitoring should be conducted on a biennial schedule.
7. **Annually assess overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, other studies, etc.).** The recovery plan must be evaluated periodically to determine if it is on track and to recommend future actions. As more is learned about the species and as conditions change, recovery objectives may need to be modified.

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PART III

IMPLEMENTATION SCHEDULE

Priorities in column one of the following Implementation Schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
2. Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

COE - U.S. Army Corps of Engineers
EPA - U.S. Environmental Protection Agency
ES - Ecological Services Division of the U.S. Fish and Wildlife Service
FS - U.S. Forest Service
FWS - U.S. Fish and Wildlife Service
LE - Law Enforcement Division of the U.S. Fish and Wildlife Service
NRCS - U.S. Natural Resources Conservation Service
R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service
SCA - State Conservation Agencies - In North Carolina, these are the North Carolina Department of Agriculture; North Carolina Department of Environment, Health, and Natural Resources; North Carolina Division of Parks and Recreation; and North Carolina Wildlife Resources Commission. In South Carolina, the South Carolina Department of Agriculture, South Carolina Department of Health and Environmental Control, and South Carolina Department of Natural Resources.
TNC - The Nature Conservancy

CAROLINA HEELSPLITTER IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
1	1.1	Utilize existing legislation and regulations to protect the species and its habitat.	Continuous	R4/ES and LE	COE, EPA, FS, SCA	2.5	2.5	2.5	
1	1.2	Work with appropriate Federal and State agencies to identify actions that could negatively affect the species and incorporate protective measures into such actions.	Continuous	R4/ES	COE, EPA, FS, SCA, NRCS	3.0	3.0	3.0	
1	1.4	Encourage establishment of outstanding resource water designations and other protective strategies as a means of protecting the species.	Ongoing	R4/ES	COE, EPA, FS, SCA, TNC, NRCS	???	???	???	
1	2.1, 2.2, 2.3	Conduct research necessary for species' management and recovery; i.e., habitat requirements, biology, and threat analyses.	3 years	R4/ES	SCA, FS	25.0	25.0	25.0	
2	1.3.1, 1.3.2	Meet with local government officials and business interests and elicit their support for recovery.	3 years	R4/ES	COE, EPA, FS, SCA, TNC, NRCS	3.0	2.0	1.0	
2	1.3.3	Develop information and education program and present.	Ongoing	R4/ES	SCA, TNC, FS	5.0	3.5	2.0	Task duration: 1 year to develop, then continuous.
2	1.5	Consider use of land acquisition to protect the species.	Ongoing	R4/ES	SCA, TNC, FS	???	???	???	

CAROLINA HEELSPLITTER IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
See comments	2.4	Based on biological and threat analyses, investigate need for management and implement where needed.	2 years	R4/ES	COE, EPA, FS, SCA, NRCS	---	25.0	25.0	Priority 1, 2, or 3, depending on result of 2.1, 2.2, and 2.3.
2	2.5	Determine number of individuals required to maintain viable population.	1 year	R4/ES and LE	Contract	---	---	???	
2	3	Search for additional populations and suitable habitat for reintroductions.	Ongoing	R4/ES	FS, SCA, or Contract	6.0	6.0	---	
2	4	Develop artificial holding and propagation techniques; reintroduce species into historic habitat; and, if needed, augment existing populations.	Ongoing	R4/ES	Contract	30.0	30.0	30.0	Task duration: 3 years (protection continues).
2	5	Develop and utilize cryopreservation techniques.	Ongoing	R4/ES	Contract	8.5	8.5	2.0	
2	6	Develop and implement a monitoring program.	Ongoing	R4/ES	FS, SCA	---	---	4.0	Biennial.
3	7	Annually assess recovery program and modify program and plan where required.	Ongoing	R4/ES	FS, SCA	---	---	---	

PART IV

LIST OF RECIPIENTS

The following agencies, organizations, and individuals were mailed copies of this recovery plan. This does not imply that they provided comments or endorsed the contents of this plan.

Mr. Jack E. Ravan
Regional Administrator
Environmental Protection Agency
345 Courtland Street, NE.
Atlanta, Georgia 30365

*Ms. Katherine Skinner, Director
The Nature Conservancy
North Carolina Chapter
4011 University Drive, Suite 201
Durham, North Carolina 27707

Ms. Chrys Baggett
The State Clearing House
North Carolina Department of Administration
116 W. Jones Street
Raleigh, North Carolina 27611

Mr. Elmer Whitten, Director
The South Carolina State Clearinghouse
Office of the Governor
P.O. Box 11450
Columbia, South Carolina 29211

*Dr. Bert Pittman
South Carolina Department of Natural Resources
Heritage Trust Program
P.O. Box 167
Columbia, South Carolina 29202

*The Nature Conservancy
P.O. Box 2267
Chapel Hill, North Carolina 27514

Lt. Col. Thomas F. Julich
District Engineer
U.S. Army Corps of Engineers
P.O. Box 919
Charleston, South Carolina 29402-0919

Lt. Col. Terry R. Youngbluth
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402-1890

Mr. Jim Burnette, Jr.
North Carolina Department of Agriculture
Pesticide Section
P.O. Box 27647
Raleigh, North Carolina 27611

Division Administrator
Federal Highway Administration
310 New Bern Avenue, Suite 410
Raleigh, North Carolina 27601

Division Administrator
Federal Highway Administration
1835 Assembly Street, Suite 758
Columbia, South Carolina 29201

Mr. R. Samuel Hunt III
Secretary
North Carolina Department of Transportation
P.O. Box 25201
Raleigh, North Carolina 27611-5201

Mr. Paul Cobb
Chief Commissioner
South Carolina Department of Highways and
Public Transportation
P.O. Box 191
Columbia, South Carolina 29202

Mr. Ed Frierson
South Carolina Department of Highways and
Public Transportation
P.O. Box 191
Columbia, South Carolina 29202

Cabarrus County Manager
Courthouse
Box 707
Concord, North Carolina 28025

Union County Manager
Courthouse
P.O. Box 218
Monroe, North Carolina 28110

Mr. Tom Mitchell
Duke Power Company
285 Parham Road
York, South Carolina 29745

*Director
Environmental Management Division
North Carolina Department of Environment,
Health, and Natural Resources
Archdale Building
512 North Salisbury Street
Raleigh, North Carolina 27611

*Mr. Charles R. Fullwood
Executive Director
North Carolina Wildlife Resources Commission
Archdale Building
512 North Salisbury Street
Raleigh, North Carolina 27611

*Director
Museum of Natural Sciences
Agriculture Building
1 West Edenton Street
Raleigh, North Carolina 27611

Chairman
Chesterfield County Council
208 Market Street
Cheraw, South Carolina 29520

Chairman
Lancaster County Council
904 Charles Avenue
Lancaster, South Carolina 29720

*Dr. Eugene Keferl
Department of Natural Science
Brunswick Junior College
Brunswick, Georgia 31523

U.S. Geological Survey, WRD/SR
Spalding Woods Office Park - Suite 160
3850 Holcomb Bridge Road
Norcross, Georgia 30092-2202

*Dr. Arthur E. Bogan
36 Venus Way
Sewell, New Jersey 08080

*Dr. David H. Stansbery
Ohio State University
Museum of Biological Diversity
1315 Kinnear Road
Columbus, Ohio 43212-1192

Director
Office of Hydropower Licensing
Federal Energy Regulatory Commission
825 North Capitol Street, NE.
Washington, DC 20426

Kershaw County Council
1121 Broad Street
Camden, South Carolina 29020

Mr. Carl Tucker
P.O. Box 7
Pageland, South Carolina 29728

Ms. Debra Owen
North Carolina Department of Environment,
Health, and Natural Resources
Water Quality Section
4401 Reedy Creek Road
Raleigh, North Carolina 27607

*Dr. G. Thomas Watters
Aquatic Ecology Laboratory
Ohio State University
1314 Kinnear Road
Columbus, Ohio 43212

Mr. Frank Tursi
Science Reporter
Winston-Salem Journal
418 N. Marshall
Winston-Salem, North Carolina 27102

Mr. Robert Abernethy
Halliburton Nus Environmental Corporation
900 Trail Ridge Road
Aiken, South Carolina 29803

Mr. Glen Gaines
Savannah River Forest Station
P.O. Box 710
New Ellenton, South Carolina 29841

Mr. W. M. Baughman
Westvaco Corporation
1226 Cooper Store Road
Moncks Corner, South Carolina 29461

*Dr. Arthur Clarke
325 E. Bayview
Portland, Texas 78374

Mr. Fred Kinard
Westvaco Corporation
P.O. Box 1950
Summerville, South Carolina 29484

Mr. Robert Wright
Research Triangle Institute
P.O. Box 12194
Research Triangle Park, NC 27709

Haile Mining Company, Inc.
P.O. Box 505
Kershaw, South Carolina 29067

Mr. Larry Robinson
U.S. Natural Resources Conservation Service
1835 Assembly Street, Room 950
Columbia, South Carolina 29201

Dr. Lynn Wike
Savannah River Technology Center
Building 773-42A
Aiken, South Carolina 29802

Environmental Protection Agency
Hazard Evaluation Division - EEB (TS769C)
401 M Street, SW.
Washington, DC 20460

Project Manager (7507C)
Environmental Protection Agency
Endangered Species Protection Program
Environmental Fate and Effects Division
Office of Pesticide Programs
401 M Street, SW.
Washington, DC 20460

Mr. Rich Owings
North Carolina Arboretum
P.O. Box 6617
Asheville, North Carolina 28816

*Ms. Linda Pearsall, Director
North Carolina Department of Environment,
Health, and Natural Resources
Natural Heritage Program
P.O. Box 27687
Raleigh, North Carolina 27611

*Mr. Randy C. Wilson, Section Manager
Nongame and Endangered Wildlife Program
North Carolina Wildlife Resources Commission
P.O. Box 118
Northside, North Carolina 27564

*Program Manager
Division of Boating and Inland Fisheries
North Carolina Wildlife Resources Commission
Archdale Building
512 N. Salisbury Street
Raleigh, North Carolina 27604-1188

Mr. Alan Smith
P.O. Box 887
Mars Hill, North Carolina 28754

*Dr. James Layzer
U.S. Fish and Wildlife Service
Tennessee Cooperative Fishery Research Unit
Tennessee Technological University
Box 5114
Cookeville, Tennessee 38505

*U.S. Forest Service
Wildlife, Fisheries, and Range
1720 Peachtree Road, NW.
Atlanta, Georgia 30367

Traffic U.S.A.
World Wildlife Fund
1250 24th Street, NW., Suite 500
Washington, DC 20037

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814

*Mr. Tom Kohlsaatt
South Carolina Department of Natural Resources
P.O. Box 167
Columbia, South Carolina 29202

Ms. Shirley Ruffin
South Carolina Electric and Gas Company
Environmental Services Department
Mail Code 175
Columbia, South Carolina 29218

Ms. Juliet Mason
Tetra Tech, Inc.
4700 King Street, Suite #500
Alexandria, Virginia 22302

Mr. Vernon Osteen
Westinghouse Savannah River Company
Building 742A
P.O. Box 616
Aiken, South Carolina 29802

Mr. Edward S. Syrjala
P.O. Box 149
Centerville, Massachusetts 02632

Mr. Jeff Holland
2801 Yorkmount Road, Suite 300
Charlotte, North Carolina 28208

Ms. Alice L. Gustin
Publisher/Editor
Land Use Chronicle
P.O. Box 468
Riverton, Wyoming 82501

*The Nature Conservancy
Eastern Regional Office
201 Devonshire Street, 5th Floor
Boston, Massachusetts 02110

*The Nature Conservancy
1815 N. Lynn Street
Arlington, Virginia 22209

*Dr. Gary B. Blank
North Carolina State University
Box 8002
Raleigh, North Carolina 27695-8002

Mr. Charles P. Nicholson
Tennessee Valley Authority
400 West Summit Hill Drive
Knoxville, Tennessee 37902-1499

*Ms. Leigh Ann McDougal
U.S. Forest Service
Blacksburg Ranger District
110 Southpark Drive
Blacksburg, Virginia 24060

*Ms. Kelly Russel
U.S. Forest Service
Francis Marion and Sumter National Forests
4931 Broad River Road
Columbia, South Carolina 29210

*Ms. Donna Ray
U.S. Forest Service
Long Cane Ranger District
810 Buncombe Street
Edgefield, South Carolina 29824

Mr. Bob Bowie
Soil Conservation Service
304 Gray Street
Edgefield, South Carolina 29824

Mr. Billy Fleming
South Carolina Department of Natural Resources
Route 3, Box 228
Abbeville, South Carolina 29620

M. L. Haltwanger Lumber Co., Inc.
Route 2, Box 42
Newberry, South Carolina 29108

International Paper Company
Augusta Operations
Augusta, Georgia 30913

*Ms. Patricia Jerman
Executive Director
South Carolina Wildlife Federation
715 Woodrow Street
Columbia, South Carolina 29205

Mr. Wayne Adams
County Administrator
215 Jetter Street
Edgefield, South Carolina 29824

Mr. Steve Odom
Greenwood Clemson Extension
P.O. Box 246
Greenwood, South Carolina 29648

Mr. Bettis Rainsford
1081 One-half Court House Square
Edgefield, South Carolina 29824

Mr. Mitchell S. Scott
Cullum's Lumber Mill, Inc.
P.O. Box 535
Allendale, South Carolina 29810

*Mr. Dale Soblo
The Nature Conservancy of South Carolina
P.O. Box 5475
Columbia, South Carolina 29250

*Mr. Jim Sorrow
South Carolina Department of Natural Resources
128 Wills Court
Central, South Carolina 29630

Stone Container Corporation
217 Cedar Road
Lexington, South Carolina 29072

Mr. Tony Watson
Clemson University County Extension Office
County Agriculture Building
Edgefield, South Carolina 29824

Mr. Frank White, Chairman
Abbeville Forestry Association
P.O. Box 224
Troy, South Carolina 29848

Mr. Ben Wigley
NCASI
Department of AFW
Clemson University
Clemson, South Carolina 29634-0362

Mr. Dennis Testerman
Cabarrus Soil and Water Conservation District
745 Cabarrus Avenue, W.
Concord, North Carolina 28027-6850

Mr. Jimmy Bullock
c/o Union Camp Woodland
P.O. Box 1391
Savannah, Georgia 31402

Ms. Anne Coan
Natural Resources Division Director
North Carolina Farm Bureau Federation
P.O. Box 27766
Raleigh, North Carolina 27611

Mr. Fred C. Schmidt
Head, Documents Department - KW
The Libraries
Colorado State University
Fort Collins, Colorado 80523-1019

Mr. Chris Kempton
P.O. Box 1368
Clemson, South Carolina 29633

Mr. Andrew Haines
ROY F. WESTON, Inc.
Life Systems Department
Building 5-1
One Weston Way
West Chester, Pennsylvania 19380-1499

Mr. Mark Brosseau
101 W. River Road, #200
Tucson, Arizona 85704

Federal Highway Administration
Office of Environmental Policy
Environmental Analysis Division
400 Seventh Street, SW., Room 3240
Washington, DC 20590

*Directorate for Biological, Behavioral, and Social Sciences
National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

Dr. Harriet Gillett
World Conservation Monitoring Centre
219 Huntingdon Road
Cambridge CB3 0DL
United Kingdom

*Independent Peer Reviewers